Investigating the Effectiveness of Montmorillonite-Alginate Nanocomposite Beads in the Removal of Anionic Tartrazine and Amaranth Azo Dyes From Wastewater, Quantified via UV-Visible Spectrophotometry

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Annually, 60,000 tons of textile wastewater are discharged into waterways. Azo dyes constitute a major proportion, polluting waterways by inhibiting light penetration; impairing marine organism metabolism; and degrade into lethal aromatic amines. Adsorption is one effective mechanism used in industrial filtration infrastructure. This investigation aimed to explore the adsorption kinetics and efficiency of nanocomposite beads composed of alginate and montmorillonite clay (MMT) in removing the azo dyes: Amaranth and Tartrazine. MMT powder and sodium-alginate mixtures were physically cross-linked with calcium chloride droplets to form high surface area, adsorptive beads. Through microcentrifugation, preliminary experiments determined the optimal MMT: Alginate bead composition, and pH for maximal dye adsorption. Subsequently, a static adsorption design was employed to measure change in dye concentration in the presence of the beads across 90 minutes. Measurements used UV-Visible Spectrophotometry at 425nm and 520nm (Tartrazine, Amaranth). This study found that when comparing maximal adsorption efficiency of azo dye, beads with MMT were significantly more effective than pure alginate composites (93.85% vs. 77.42%, respectively). Furthermore, there was greater fitting of results to the Pseudo-Second-Order kinetic model (PSO) (R-squared =0.9985) compared to the Pseudo-First-Order kinetic model (PFO) (R-squared =0.9625). This suggests the beads' key adsorption mechanism is chemisorption, allowing for strong, irreversible adsorption of azo dye. Therefore, it was concluded that MMT-Alginate beads are highly effective in azo dye removal, utilizing chemisorption. Further research is needed to determine their large-scale applicability, and adsorption-selectivity in wastewater.

Awards Won:
Fourth Award of $500